King County Regional Infiltration/Inflow Control Program
Local Agency Workshop #5 - Summary
Tuesday, February 27 and Thursday, March 1, 2001

Background
The King County Regional Wastewater System includes wastewater interceptors, pump stations, treatment plants and outfalls. Thirty-four politically and administratively independent Local Agencies discharge wastewater from their systems to this King County regional wastewater system. Increased wastewater flows within this vast service area have used significant portions of, and in some cases have exceeded, the capacity of existing County facilities. The Regional Wastewater Services Plan (RWSP) has documented that excessive infiltration and inflow (I/I) into the system claims a significant portion of facility capacity during wet weather conditions. To protect the environment and accommodate the needs of Local Agencies, a balance must be achieved between the expansion of County facilities and the rehabilitation of County and Local Agency collection facilities. In addition, a structure for financing the costs of the necessary capital improvements in a manner acceptable to all participants must be devised.

To involve the Local Agencies in these decisions and to establish an I/I Control Program that works to resolve these issues, a series of participatory workshops has been scheduled throughout the King County Regional I/I Control Program. To date, five of 14 workshops have been held to introduce participants to the issues, determine criteria for pilot project selection, address technical, financial, and cost sharing issues, and describe modeling of wastewater flows.

Local Agency Workshop #5 was offered twice: first, on Tuesday, February 27 at the Northshore Utility District in Kenmore, Washington, and, second, on Thursday, March 1 at the Tukwila Community Center in Tukwila, Washington. A separate attendance sheet for each session is attached to this summary.

The following is a general summary of the Workshop. The summary is followed by a combined list of questions and answers from the two Workshops.

Workshop Purpose
Workshop #5 highlighted King County's new flow model, MOUSE, and modeling methodologies related to the I/I Control Program. Also featured was an update on various Program elements currently underway.

Specific questions and topics addressed at this Workshop included:

- Why should we model?
- What can models do and how do they work?
- Which model should we use?
- Model development and calibration
- Model application: comparing model basins and mini-basins
- Model application: wastewater facility planning

A technical guidance manual was prepared to provide more detailed information on the modeling concepts, parameters and assumptions to be applied in the I/I Control Program. One copy of the

Modeling Technical Guidance Manual was distributed at the Workshop to each Agency in attendance. Second copies are available by contacting King County's Erica Herrin, (206) 684-1138. Single copies will also be distributed to Local Agencies that did not attend either session of Workshop 5.

Welcome and Introductions
Gunars Sreibers, King County's Regional I/I Control Program Manager, welcomed attendees and gave a brief introduction to the day's topic, flow modeling. He emphasized that King County intends to continue working closely with each of the 34 Local Agencies on all aspects of the Program. The County hopes to get guidance on policy decisions from Local Agencies at all stages of the Program.

Program Update and Workshop Overview
Mr. Sreibers reviewed the I/I Control Program status and schedule. He explained that I/I flow monitoring efforts have been challenged because this has been the area's third driest winter on record. While the 807 flow monitors gathered some useful dry weather data, there is a lack of information on rainfall-induced infiltration (RDII). As a result, the selection of pilot projects will be delayed a year. In addition, a request will be submitted to the Regional Water Quality Committee for supplemental funding to install the 807 flow monitors again next wet season. Certain activities in the I/I Control Program are expected to continue in spite of the dry weather, including efforts related to modeling the system.

Mr. Sreibers also informed participants that EPA's satellite system sewer overflow regulations would likely be implemented in the relatively near future. These will affect agencies that discharge sewage to larger regional sewer systems. The regulations are expected to affect the King County Regional System and the associated Local Agencies. Mr. Sreibers also mentioned that the County was pursuing federal funding to support additional pilot projects and that initial contacts with Washington congressional representatives had been positive.

Mr. Sreibers explained that the purpose of the day's workshop was to show Local Agencies how the new flow model works and the methodologies that would be applied. Details, including the assumptions behind the models, would be provided to Local Agencies to demonstrate how models estimate I/I in the wastewater system.

Why Should We Model?
Gunars Sreibers, Regional I/I Control Program Manager
Mr. Sreibers explained that computer modeling would be an essential component of the I/I Control Program's effort to design an optimal I/I reduction program. Existing sewer system information, future conditions, and I/I reduction alternatives would all be simulated using computer models to assess the needed conveyance facility needs under various conditions. This information would feed the economic analysis that would be used to define the optimal I/I Control Program from an economic standpoint. Policy, environmental, and contractual considerations would be considered in conjunction with the economic analysis to develop a recommended I/I reduction program.

<u>Why Does King County Estimate Peak Flows?</u>
The existing Local Agency/County contracts require the County to take sewer flows from the Local Agencies. Although a clause in the contracts allows the County to place a surcharge on I/I

above a given amount, there is no upper limit on how much flow the County will take. King County wants to avoid backups into Local Agency systems when receiving these flows. It is equally important that County systems not overflow. The proposed federal Sanitary Sewer Overflow (SSO) rules provide further motivation for the County to design and maintain a system to convey peak flows without overflows.

During the RWSP process, King County adopted a 20-year design standard for the conveyance system. This means that the system would be capable of conveying the peak flow that is expected once every 20 years. In other words, the system would be designed to convey the peak hourly flow that has a 5% chance of occurring in any given year. To accomplish that goal, the 20-year peak flows throughout the service area must be estimated.

Not only does the 20-year peak flow need to be estimated for the existing system, but future conditions must also be accounted for because of the rapid growth in the region. The expected future flows will drive the need for upgrades in the wastewater conveyance system.

Estimating Peak Flows

Bob Swarner, King County Hydraulics and Modeling Supervisor

This presentation explained the advantages and limitations of estimating peak flows in one of three ways:

1. Flow monitoring
2. Standard flow factors or peaking factors
3. Modeling (with limited flow monitoring)

Flow Monitoring

If a 20-year peak flow were to be estimated using only flow data, a long-term record of flow would be required (about 20 years of data) to provide a high level of confidence in the estimate. There is insufficient historical rainfall and flow data from local basins to estimate peak flows from measurements at this time. Furthermore, even if a long record of rainfall and flow existed, it would be of limited value if there had been significant changes in the basin. The response of the system to I/I 15 or 20 years ago might have been quite different from what it is today if significant new development or degradation has occurred in the basin in the meantime. Thus, using a long-term historical flow record to represent the basin as it currently exists may be a faulty assumption.

It is difficult to assess capacity restrictions or changes in system performance due to operational improvements using only flow data.

Peaking Factors and I/I Rates

Sometimes peak flows are estimated using a flow factor that is multiplied by the average flow – e.g., a 4:1 peaking factor or a 6:1 peaking factor multiplied by the average wet weather flow. This approach is simple, but it is unknown what peaking factor most accurately represents the I/I response with a 20-year return interval. In addition, this approach does not account for the differences in I/I response found throughout the King County service area.

Standard I/I rates are subject to the same deficiencies that the peaking factors exhibit. For example, an I/I rate of 1100 gallons per acre per day could be applied across the service area, but

it may not represent the 20-year peak I/I from any given basin. The peak I/I rates that are expected once every 20 years still must be estimated by an independent approach.

Modeling

Modeling can estimate peak I/I response using limited rainfall and flow data. Modeling can also indicate how much of the I/I is infiltration and how much is inflow. Modeling provides the flexibility to study a variety of system conditions and flow rates and allows consideration of conditions that cannot reasonably be measured during a limited monitoring period.

Modeling Objectives

The objectives of the King County I/I Control Program modeling effort are to:

1. Estimate Regional and Local Agency I/I flows for different flow conditions
2. Identify the need for new conveyance facilities
3. Predict the system response to I/I rehabilitation scenarios, and
4. Establish the optimum level of Local Agency I/I rehabilitation vs. regional system expansion.

Workshop participants were then presented with a system map showing approximately 150 modeling basins and the pipes that convey wastewater to the treatment plants. Once the I/I response from each of the modeling basins is calibrated, then the flows can be simulated through the King County pipe network to the treatment plants. This can be done for existing and future conditions. Then needed conveyance improvements can be determined to prevent backups and flooding at the 20-year peak flows.

Once this "baseline" of needed conveyance facilities is determined, various I/I rehabilitation scenarios can be simulated to determine the resulting (reduced) conveyance facility needs. The estimated costs of the I/I rehabilitation efforts will then be weighed against the lower costs of downstream conveyance facility upgrades and an optimum I/I control effort will be targeted.

What Can Models Do and How Do They Work?

Bob Swarner, King County Hydraulics and Modeling Supervisor

Models can estimate peak flows, locate general areas of infiltration and inflow, locate conveyance restrictions, and help project necessary improvements. Models cannot tell exactly where the I/I originates (e.g. from a broken sewer main or from a manhole/pipe connection) but a calibrated model can provide a good indication of whether the I/I is infiltration or inflow. A model can also provide an indication of how much of the infiltration is rainfall-dependent infiltration and how much is a longer-term groundwater infiltration response.

Requirements for I/I Modeling

Key items required for successful I/I modeling include:

1. Good rainfall data –73 rain gauges have been installed around the service area since last fall;
2. Good flow data – 807 flow meters were also installed this past wet season;
3. Large storms to trigger the various I/I responses;
4. Repeated storms to ensure simulation of different rainfall conditions;
5. Varying groundwater conditions – so that the magnitude and timing of the groundwater I/I response can be simulated.

It is important to remember that an I/I model must be calibrated prior to using its results. There are no models that accurately estimate I/I response without first being calibrated. Furthermore, models do not indicate exactly where the I/I is coming from. Field verification is required prior to beginning the design of an I/I rehabilitation project. Results from an I/I model can provide important information on how to target a field investigation. Model results can provide a good indication of whether the I/I rehabilitation effort will be focused on removing infiltration or inflow from a given basin and can be helpful in estimating the costs of an I/I reduction program.

Several graphs were then presented showing how a model can simulate the flow response at various locations around the King County service area. (See Workshop #5 PowerPoint slides, attached.) Several of the large storms since 1990 were displayed, showing that a model can accurately simulate I/I and base flow responses for many rainfall conditions using the same model basin parameters. Good matches of measured and simulated flows were displayed for the South Plant at Renton, Juanita Pump Station, and three interceptors in Auburn and the Carkeek Pump Station and Treatment Plant. Simulation results and metered flow from the large storms of November 25-26, 1998; February 8, 1996; April 4, 1991; November 24, 1990; and January 9, 1990 were presented, along with the model and meter responses to smaller storms.

The components of flow, including inflow, rainfall-dependent infiltration, and groundwater infiltration, were displayed on some of the graphs to show how the model can identify the types of I/I contributing to the peak flows.

Which Model Should We Use?
Mark Lampard, King County
King County recognized early on that there would be a substantial modeling effort as part of the I/I Control Program and created a Modeling Group to address two options available to them: make some improvements to the King County model or select a commercially available software package.

The current King County model has continuous simulation capability, simulates I/I flows well, has a high level of detail and customization, and was developed to model I/I in the Pacific Northwest. King County is not dependent on a vendor for customization when additional features are needed. The model has been used successfully in estimating RWSP conveyance needs in addition to the planning and design of conveyance and storage projects throughout the service area.

There are two major improvements to the King County model that would be needed to make the model accessible to the Local Agencies: moving the model to a PC platform from its current alpha mini-computer and adding a graphical user interface for model input and output. Making the changes to the model and making it available to the Local Agencies and/or the public would involve software maintenance issues for the Modeling Group. King County felt that getting into the software business would be a major resource commitment beyond the primary tasks of the Modeling Group. Based on these and other considerations, King County decided to investigate commercially available software packages with continuous I/I modeling capabilities.

King County began its investigation by initiating an RFP process for selection of a hydrologic and hydraulic software package to be used for the I/I Control Program and other modeling efforts. For example, staff from King County's Modeling Group participated in the City of

Seattle model selection process in 1998 and 1999, giving them a good overview of the capabilities available in the marketplace. The RFP focused on technical capabilities and documentation, the companies' and products' histories based on user interviews, the cost of the packages, and a demonstration provided by each vendor.

For the model demonstrations King County provided the vendors with needed data to set up and calibrate their hydrologic model. During the on-site demonstrations by the vendors, King County provided additional rainfall and flow data not originally supplied to validate the calibrations. This test provided King County with valuable information about how the models performed outside of the calibration period.

Based on the RFP process, King County selected the MOUSE (Modeling Of Urban SEwers) model from the Danish Hydraulic Institute (DHI). MOUSE is a tested and proven product that has been developed over the last 20 years and has been widely used internationally and in the USA. As part of the contract with DHI, the model is available to the component Local Agencies at a negotiated cost for the duration of the I/I Control Program.

MOUSE is PC and Windows based, has a graphical user interface for both input and output, a results viewer, and a very flexible structure. The flexible structure allows for customization of the model for specific client needs. The software consists of modules that perform specific tasks in the modeling process.

The hydrologic model consists of "MOUSE Runoff" for simulation of surface flow and RDII for infiltration into pipe systems. The hydrologic model is capable of continuous simulation and will be the primary tool used for estimating I/I in the modeling basins established and monitored for this project.

Output from the hydrologic model can be routed to the hydraulic model "MOUSE HD." "MOUSE HD" is one dimensional, gradually varied, unsteady flow model that is capable of computing flow and water surface elevations in complex pipe and storage networks. "MOUSE HD" is a very powerful tool for analysis and design of hydraulic systems.

The I/I Control Program is currently using the hydrologic and hydraulic modules. The Real Time Control module, "MOUSE RTC," will be used for conducting additional analyses as the I/I Control Program progresses. There is also a water quality and sediment transport module called "MOUSE TRAP" that can be used for prediction and analysis of sediment and odor problems in hydraulic systems.

Samples of the hydrologic and hydraulic output were shown.

Break for Questions and Answers (see Questions and Answers Section)

Model Development and Calibration

Mike Morgan, Modeling Manager, Earth Tech Team

To date, the modeling effort has been focused on testing the capability of the software and developing protocols for using the model during the I/I Control Program. The Medina basin (service area tributary to the Medina pump station) was selected from a limited number of places where adequate data were available to support model testing.

King County has been measuring flows at the Medina pump station for a number of years, making it attractive for use during the testing process. Adequate data were available for both calibration and validation. The MOUSE model was calibrated using measured flow and rainfall data from the 1989/1990 wet season. Calibration consists of adjusting model parameters so the model results match the measured flow results. The model simulates the process by which rainfall is transformed into the flow that leaks into the sewer system and is contributed by the basin.

In general, the key to model calibration is matching the model results to measured flows that occur under a variety of conditions. Even though King County is most interested in peak flows, it is also important during calibration to match the model results to measured hydrograph volume and hydrograph shape. After completing the calibration, other measured flow and rainfall data were used to validate the model. Validation is a way to test the calibration. It consists of using the calibrated model to simulate another time period without adjusting the model parameters in any way to match measured flows.

In this case, flow data available for model validation were collected during one of the larger storms on record, January 1990. The results of the validation demonstrated that with adequate calibration it is possible to use the model to estimate flows resulting from larger storms than were used during calibration.

The flows simulated with the hydrologic model can be used as input to the hydraulic model. The simulated flows can also be used to estimate the amount of I/I from infiltration vs. inflow.

Model Application: Comparing Model Basins and Mini-Basins
Mark Lampard, King County; Eddie Speer, Earth Tech Team
The need for the 20-year design flow was briefly explained. That standard was adopted as part of the RWSP. It allows assessment of facility performance on the basis of how often the system is at or near capacity and provides a basis for planning and facility design.

The two methods available for determining the 20-year design flow were described: either monitor for a long period of time, or simulate using a long term response with a calibrated model. Both of these analyses rely on probability analysis.

The advantages of using the long term simulation are:

- The antecedent conditions of the modeled sewer basin are inherent to the analysis due to the variety of storms and the duration of the calibration and simulation period.

- The model can simulate the response to short, intense storms or long, gradual wet periods followed by one or two days of heavier rain fall.

- The probability is applied to the flow output instead of to rainfall. The selection of storm duration and intensity to determine the peak response is not needed in the long-term simulation.

The process for the long-term simulation was summarized as follows: the model is calibrated using local rain and flow data; the calibrated model is run for a long period of time using a long-term rainfall record; and statistical analysis is applied to the long-term simulation output.

The long-term rainfall record used for the simulation is the Sea-Tac airport rain gauge. The Sea-Tac gauge is the longest rainfall record available that is representative of the lower elevations of the Puget Sound area. Hourly rainfall is available beginning in 1948 through 1999, a period of 51 years.

The analysis of the long-term output involves selecting roughly 300 flow peaks by applying a threshold value. The peaks are rank ordered and plotted against the log of their return period. A best fit line is determined by linear regression on the top flow with a return period of one year and greater. These are the top 51 peak flow values. The flow for a given return period is calculated using the best fit line equation or graphically from the plot.

Two graphs were presented. The first showed flow peaks below and above the threshold value. The second demonstrated the plotting of the points, the best fit line, and how the graph can be used to estimate the 20-year peak flow.

Mr. Speer explained that the I/I Control Program is committed to reducing I/I before it enters the conveyance system. The modeling basins average around 1000 acres, with about half of them larger than that size. This is too large an area to perform detailed engineering studies with sewer TV techniques, smoke testing, etc. To hone in on the specific areas, a smaller geographic region must be identified so that I/I can be further assessed.

In order to provide a detailed look at specific I/I conditions, about 600 smaller basins were defined in the study area. These basins were called “mini-basins” to differentiate them from the approximately 150 larger basins that will be calibrated with the hydrologic model. The smaller mini-basins were monitored for a 10-week period during the height of the expected 2000-2001 rainy season.

The rehabilitation techniques for fixing infiltration problems are fundamentally different from those for fixing inflow problems. Since costs must be estimated, information is needed on where the excess flows are the result of infiltration, the result of inflow, or both. The model provides us with the components of flow that can be used to assess what is infiltration and what is inflow. However, the model is at a scale larger than the mini-basins, so King County will use the information the model provides to allocate the relative proportions of I/I to the measured flow rates observed at the mini-basin levels.

Distribution of flows requires looking at measured flow responses for specific rain events at the mini-basin level and comparing the responses to that at the model basin level. A specific maximum in measured response from the mini-basin curve is compared to the components of I/I at the model basin level.

Once these relative proportions of I/I are identified, King County will use them in conjunction with the 20-year peak flow (identified at the modeling basin level) to determine the extent to which each mini-basin contributes I/I to that 20-year peak. This very specific level of detail will allow for uniform coverage of the entire study area.

Break for Questions and Answers (see Questions and Answers Section)

Model Application: Wastewater Facility Planning
Mike Morgan and Ed Pier, Earth Tech Team
The model can also be used to evaluate future conditions. Projecting future flows is necessary to determine future facility needs. This same process was completed during development of the RWSP. It will continue to support the planning efforts underway in the Conveyance System Improvements (CSI) program and the I/I Control Program.

Projecting future flows allows for quantifying needed conveyance and treatment capacity and estimating timing of conveyance capacity. In the section covering calibration, the types of flows represented by the model were discussed. There will be additional flows contributed in the future. In general, there are three types of additional flows expected in the future:

1. Wastewater from additional population
2. I/I from newly constructed local sewers
3. I/I from system degradation.

Because these flows will occur in the future, some assumptions must be made about the timing, magnitude and location of these flows. Population forecasts from the Puget Sound Regional Council will be used to forecast wastewater flows from additional populations. GIS techniques will be used to make assumptions on currently unsewered areas and the extent to which these areas will become sewered in the future.

With the ability to model future flows emanating from the modeling basins, various I/I reduction scenarios can be evaluated to determine benefits of potential capital programs.

Break for Questions and Answers (see Questions and Answers Section)

Wrap up—What Happens Next?
Marcos Lopez, Earth Tech Team Program Manager and Ed Pier, Earth Tech Team
King County has completed its flow monitoring for the 2000-2001 wet season and is removing all temporary monitors. Although there was very little rain, a good baseline for dry weather flow has been established. While some I/I response was observed in virtually all the mini-basins, there was not enough for reliable analysis.

Consequently, some adjustment to the original I/I Control Program will have to be made:

1. King County is pulling all Tier 2 and 3 meters out early to save on costs. Also, King County is assuming operation and maintenance of Tier 1 (Long Term) meters somewhat ahead of schedule;
2. Based in part on Local Agency input to MWPAAC, King County staff is going to King County Council with a request for supplemental funds to remonitor next winter for 2.5 months, installing all 807 meters.

This plan is still subject to change. If it carries through, it will have other impacts on the I/I Control Program schedule:

1. Because King County intends to remonitor next year, and in response to Local Agency input via MWPAAC, King County is deferring pilot project selection and construction a

year, until after the 2001-2002 wet weather flow data are collected. As a result, the Pilot Project Selection Workshop scheduled for April will not be held.
2. Tasks that are dependent on pilot project results, such as a recommendation of rehabilitation methods and I/I Control Program cost estimating, will also be deferred.
3. King County intends to continue with modeling tasks - such as basin characterization and dry weather calibration - that don't require wet weather data. So Earth Tech Team members will still be contacting Local Agencies for information on local systems and basin characteristics.
4. Wet weather calibration and routing peak flows will have to wait until good, wet weather data are collected.

The supplemental funding request has been taken to our Congressional delegates in Washington, D.C. and is now in the selection process for budget appropriations there. Most of the effort for the remaining I/I Control Program tasks, including development of Cost Sharing Alternatives, Cost Benefit Analysis, and Rate Design, will also be deferred a year until after the next round of flow monitoring.

Two workshops will be held later this year: (1) Draft Design Standards and Rehabilitation Contracting Alternatives (mid-summer); and (2) Policies on Rehabilitation on Private Property and confirmation of Design Standards and Contracting Alternatives (December).

The modeling will play a critical role in defining the extent and cost of the ultimate rehabilitation program. Local Agency understanding and acceptance of the modeling approach is important and King County wants Local Agency input on the assumptions and methodologies presented today. To facilitate this process, King County has prepared and distributed a Technical Guidance Manual on the modeling.

Questions and Answers

February 27, Northshore Utility District

1. **Q: Is the modeling package available to Local Agencies? If so, what is the cost?**
   A: Yes, the model is available to the Local Agencies. As part of the negotiated contract with Danish Hydraulics Institute (DHI), Local Agencies can obtain the full package for about $10,000 with all features; this is about half the list price. Local Agencies may further reduce this cost if they determine they don't need the full package of options that King County purchased.

2. **Q: How can we get information on the exact specifications, if our Local Agency wants its own modeling system?**
   A: Contact Bob Swarner at (206) 684-2072 for details. King County will put the Local Agency in touch with DHI, and the Local Agency can make a decision after their modeling people talk with DHI. If you desire, County staff can assist the Local Agency in determining its modeling needs.

3. **Q: What is the significance of using a 20-year flow event in the models?**
   A: That is the design standard used for all King County facilities as established in the RWSP. A 100-year flow standard would be too expensive, and a five-year flow standard would lead to too many overflows.

4. **Q: Are the data from SeaTac rainfall updated with CALAMAR data?**
   A: CALAMAR data will be available for software calibration and the Sea-Tac rain gauge data will be applied to the model for long-term simulations. This will give modelers a reasonable estimate of a 50-year rainfall pattern for the lower Puget Sound basin.

5. **Q: A threshold flow was described for establishing the data-pool of peak flows used in determining a 20-year flow event. How was that threshold flow selected?**
   A: King County looked at the flow pattern, peaks and lows, and opted for 5.25 cubic feet per second (CFS) as a threshold since it provids a large yet manageable pool of data with which to perform frequency analysis. [Lowering or raising the threshold does not change the frequency or return interval of the large peaks.]

6. **Q: Are you assuming rainfall over the County is uniform and happening at the same time? If not, how will you take variable conditions into account?**
   A: With the CALAMAR system, the scaling of rainfall throughout the service area shows enough sensitivity that it will enable us to estimate rainfall over each modeling basin for calibration purposes. The Sea-Tac rainfall record will be used for the long-term simulations because it is the longest rainfall record available for the lowlands of the Puget Sound basin. This should give a representative long-term record over most of the modeling basins.

   King County is aware of the variability of rainfall throughout the service area, particularly rainfall volumes by return period for given storm durations in addition to annual rainfall volume variation. The modelers will be reviewing how this variation has been handled by other regional hydrologic modeling efforts and will determine how much adjustment is appropriate for areas that appear to vary from the Sea-Tac record. This can be accomplished through the use of published rainfall/return period data in addition to comparing shorter-term

rainfall records at different locations surrounding the service area to the same period of the record for the Sea-Tac gauge. The gauges that may be used for comparison are Landsburg, Carnation, Everett, and Tacoma.

7. **Q: Can you explain how the Regional Wastewater Services Plan (RWSP) sensitivity analysis was done?**
   A: In the RWSP, I/I was estimated using about 100 modeling basins. However, the basins were calibrated using only about 12 flow meters. The I/I Control Program will provide much finer resolution of the I/I response throughout the service area. The RWSP analysis used Sea-Tac rainfall data on specific regional facilities and their contributing basins.

8. **Q: How much I/I are you assuming for new sewer areas?**
   A: The modelers will look at flow monitoring results from several of the newest metered areas. This year the Earth Tech Team will conduct a national survey of other municipalities and will look to see what values those agencies have measured.

March 1, Tukwila Community Center

1. **Q: What level of storm do you need in order to estimate a 20-year flow event?**
   A: A 20-year flow event can be caused by a broad variety of storm conditions. The degree of the soil moisture before any given rain event (antecedent conditions) will have a significant effect on how much of and how fast a storm's rainfall is stored or absorbed into the soil and how much becomes I/I. The closer the modelers get to a 20-year flow event during the calibration period, the more certainty modelers have on a 20-year peak flow estimate. With several different levels of storms, modelers can extrapolate from a one-year flow event to predict a 20-year event with reasonable accuracy (approximately within 15%).

2. **Q: How well does the new (MOUSE) model match the old flow model?**
   A: Quite well. King County has just begun using MOUSE and is pleased with how closely staff have been able to calibrate it so far - e.g., for the results King County got running the model on the North Mercer basin during the model selection process. King County will also be comparing information from the new model to information from the previous King County model to check how well they match. King County will be glad to give Local Agencies the available data and modeling results. Local Agencies are also welcome to buy the modeling software and run the data through the model themselves. King County cannot provide a hydraulic analysis of Local Agency systems at this time but will be happy to let Local Agencies know how much I/I was measured and projected for each modeling basin.

3. **Q: Regarding software, you said the demonstration was a significant factor in your decision. What assurance can you give us that the demonstration showed the product's capacity with your data and not just the salesman's skills?**
   A: In addition to vendor's calibration, King County asked vendors to simulate an extended period based on the rain data provided by King County without the flow data for comparison. Staff compared the result from their model to evaluate the performance of the models.

King County also asked the vendors to estimate the time and cost for them to calibrate a basin, assuming their level of expertise in using the model they were selling. King County paid the vendors for their work -- up to $3,000 of model calibration cost. This way, King County not only gained information on how well the model could be calibrated to simulate different storms, but also was able to evaluate how convenient it was to use the model. It turned out that MOUSE did a good job in matching the flow for verification, and the other software package failed in this respect.

King County also requested documentation of the Rainfall Dependent Infiltration/Inflow (RDII) module and thoroughly evaluated the documentation from the vendors to make sure the software, once procured, could be examined against the documentation.

The model selection process was very thoroughly done. Local Agency staff are encouraged to contact King County staff to review the RFP details and model selection process and come to their own conclusions.

4. **Q: Does software have run-time or view-only mode? How will you provide the data for us?**
   A: King County hasn't decided how it will distribute the information. One of the reasons for this Workshop is to get feedback from Local Agencies on how they would like to get the data. The software does have a "MIKE view" module, a view-only mode, that is fairly inexpensive.

5. **Q: Regarding the modeling software selection, did you give the vendors projected flow and rainfall data?**
   A: King County gave the vendors storm data on rainfall and flows from September to December, 1995 and for February, 1996 to calibrate their models. Then they received rainfall data from February to the end of April, 1996 to run and provide simulation results. They did not have the metered flow results for this extended period, which was used for validation of their model. King County staff did the comparison after the vendors delivered their simulated flow.

6. **Q: So you didn't have actual 20-year flow data to calibrate?**
   A: No, those data were not available.

7. **Q: Do you have to re-calibrate for different storm levels?**
   A: Ideally, modelers would be able to calibrate to storm levels that bracket the conditions of interest. In reality, measured data for the higher level flows and storms are not always available. Modelers can simulate flows at different storm levels based on a calibration of several storm events. As you've seen in our presentation today, the I/I Modeling Team has achieved consistently good results simulating several levels of flow and rain events from one calibration. However, the further the event conditions are from the level of calibration, the more uncertainty there will be.

8. **Q: How much assurance do we have that the software can jump from a one-year storm to a 20-year storm correctly?**
   A: Until 20-year storm data are available, the exact level of accuracy will not be known. MOUSE has been shown to simulate flows reliably though. It is a commercial package that

is accepted and used in a number of communities and appears to give as good or better results as any of the major, commercially-available modeling software.

9. **Q: Are you 100% confident that you have the technical expertise to run the software?**
   A: Yes.
   Q: Please reassure us.
   A: King County's modelers are all highly trained in hydrology and hydraulics and are experienced modelers. In addition, King County modeling staff completed DHI's training course in the operation of MOUSE.

10. **Q: What is a 20-year storm? A one-hour, three-hour, or maybe two-day event?**
    A: The standards relate to a 20-year peak flow, not a 20-year storm event. The 20-year flow could be generated by any number of combinations of rainfall events and is a peak flow that has a 5% probability of occurring in any given year.

11. **Q: With 34 different Local Agencies and different topographies, did the basin used for modeling contain all of these topographies?**
    A: To the extent possible, yes. The modelers took variability in topography, Local Agency systems, etc., into account when establishing basins.

12. **Q: How do you differentiate between groundwater infiltration in dry cycle and rain-dependent infiltration?**
    A: Physical mechanisms are difficult to separate with the model. Taking parameters and measured flow over a season will show a pattern -- the minimum point on the curve equals groundwater infiltration.

13. **Q: Since there has been so little rain, is this a good year to establish baseline groundwater levels?**
    A: It is a good year for dry weather data, but there are almost no data on rainfall's effects on soil moisture or groundwater. Since groundwater infiltration is low, there are good data on inflow from this season.

14. **Q: How does the model handle diurnal wastewater flow aspects?**
    A: The MOUSE model is very flexible. The model does accept diurnal wastewater flows. However, average meter flow over a period of time at a certain hour of the day is usually used as the input. There is an hourly number to input; usually modelers compare weekday flows to weekend and even holiday flows that have different patterns. This process can be done for any or all basins.

15. **Q: Where the measured flow line on the graph disagrees with the modeled flow line, what are you measuring and where is the discrepancy?**
    A: The measured flow is from a flow meter, which directly measures fluid depth and velocity in the sewer to determine the rate of flow. The model parameters primarily include flow components based on rates assigned to population estimates, components corresponding to surface runoff, interflow from soil interstices (simulating the storage effects of varying degrees of soil moisture) and varying depths of groundwater. The model hydrograph is developed by adjusting numerous parameters of these slow and fast I/I components to achieve a best fit over an extended period of time. In other words, the model hydrograph is

adjusted to try to fit all the variations in the curve representing flow during dry periods at the same time it matches the variations and peaks in all the wet periods over an extended time range. Although the model has quite a number of parameters with which to adjust the shape of the hydrograph and achieve a reasonable match with the real flow, it is not cost effective to simulate every parameter and interaction of the parameters that occur in nature. Consequently, it is seldom possible to achieve an exact fit of the simulated flows to measured flows.

16. **Q: When do you decide that the calibration is good?**
    A: It depends primarily on three factors: 1) quality of the data—there's no point in trying to match a measured curve closer than the accuracy of the metered data; 2) diminishing return (model won't get much better with more effort); and 3) time available for calibration, since calibration is an iterative process. Another factor would be the level of accuracy required of the results—e.g., are they to be applied for design or planning level calculations?

17. **Q: The curve is too smooth; the inaccuracies of the model are not reflected in the curve. Why? [Page 25 of the PowerPoint handout]**
    A: This is largely due to the fact that it is a plotted logarithm, which decreases the discrepancies in the early portion of the graph. Also, it is not calibrated to a 20-year flow event but to a two or three-year flow event. Modelers ground-truth the information to see if it is realistic.

18. **Q: In the model, is there a coefficient of leakage?**
    A: It is not that detailed, but the model does give an indication of the leakage.

19. **Q: Should we see significant I/I from new construction? Shouldn't the PVC piping be impermeable?**
    A: You would think so. But in fact, new sewer lines are seldom completely free from I/I. The amount of resources put into new lines varies greatly by Local Agency. Many new systems have significantly less I/I, but King County has also seen high levels from lines built in the last ten years. Local Agencies have different resources and perform variable levels of inspection; this affects how well a sewer is installed. EPA even included a factor for I/I under the sewage grant program for new sewers.

20. **Q: In projections for I/I from new construction etc., how much will you involve the Local Agencies?**
    A: Program staff rely on Local Agency input and will continue to come and ask for information. In addition, results of the modeling will be reviewed by the Local Agencies in upcoming workshops.

21. **Q: For mini-basins and model basins, why are you getting opposite results (with higher inflow for one, higher infiltration for the other)?**
    A: The examples used in the presentation were hypothetical. A model basin is typically comprised of several mini-basins. The model basin's flow represents an aggregate of the flows from its component mini-basins. Each component mini-basin will have unique flow characteristics. One of the mini-basins may not have inflow while the other mini-basins do. Thus, the model basin would exhibit inflow characteristics while the one mini-basin would not.

22. Q: This project will give us better rainfall data; will they be plugged back into the RWSP to forecast facility replacement costs that were used in developing that document?

A: King County will update all affected sections of the RWSP before it begins any I/I removal.